



Pacific Harbor Seal (*Phoca vitulina richardsi*) Monitoring at Point Reyes National Seashore and Golden Gate National Recreation Area

2009 Annual Report

Natural Resource Technical Report NPS/SFAN/NRTR—2010/345



ON THE COVER

Pacific harbor seals (*Phoca vitulina richardsi*) hauled out at Tomales Point, Point Reyes National Seashore.

Photograph by: Erin Flynn

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Golden Gate National Recreation Area
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Abstract

Pacific harbor seals (*Phoca vitulina richardsi*) are the dominant and only year-round resident pinniped in the San Francisco Bay Area, California. Long-term monitoring studies have been conducted at the largest harbor seal colonies in Point Reyes National Seashore since the mid 1970's. The objectives of monitoring each site and the population as a whole are to i) detect changes in population size, ii) detect changes in reproductive success by way of pup production, and iii) identify anthropogenic or environmental factors that may affect the condition of the population (Adams et al. 2009).

Harbor seal surveys were conducted throughout the 2009 breeding (March through May) and molting (June through July) seasons once to twice per week at the largest Point Reyes and Golden Gate harbor seal colonies, collectively referred to as Marin County locations. Members of the Harbor Seal Monitoring Volunteer Program helped to complete 227 surveys at eight Marin County locations, contributing an estimated 450 hours. During the breeding season, 2,353 adult and immature seals and 1,018 seal pups were counted at all Marin County monitoring locations. The adult and immature count is the lowest number recorded in the past 10 years. Drakes Estero had the most adults (561), followed by Tomales Bay (438) and Double Point (426). Drakes Estero and Double Point accounted for 56% (570) of pups at Marin haulouts. During the molting season, 3,556 animals were counted at Marin County locations. During surveys, 96 disturbances to seals were recorded. The most frequent causes were unknown (28.1%), motor boat (22.9%), and human on foot (21.9%). Twelve regional surveys were conducted throughout the season at locations in Sonoma, Marin, San Francisco, and San Mateo counties. Of the counties surveyed, Marin County locations accounted for 57.6% of breeding season adults/immatures, 77.6% of pups, and 70.2% of seals during the molting season.

Acknowledgements

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Finally, we are grateful for the generous contributions from the Point Reyes National Seashore Association, the David and Vicki Cox Family Foundation, the San Francisco Bay Area Inventory and Monitoring Program, and the Conservation Corps North Bay/AmeriCorps Program.

Introduction

The mission of the National Park Service is “to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (NPS 1916). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1998). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The San Francisco Bay Area Network (SFAN) includes Golden Gate National Recreation Area, John Muir National Historic Site, Pinnacles National Monument, and Point Reyes National Seashore. The network has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. Our intent has been to monitor a balanced and integrated “package” of vital signs that meets the needs of current park management, but will also be able to accommodate unanticipated environmental conditions in the future. Pacific harbor seals represent a high priority vital sign for SFAN because they are ecologically significant, have protected status through the Marine Mammal Protection Act, and are of high interest to the public (Adams et al. 2006; Adams et al. 2009).

Harbor seals were also identified as a marine mammal species most likely to benefit from the establishment of marine protected areas (MPAs) in the north central California coast region under the Marine Life Protection Act (CDFG 2009). Five MPAs were selected within Point Reyes National Seashore along with three special closure areas where harbor seals may benefit. The MPAs will be implemented in 2010 by the California Department of Fish and Game in cooperation with the National Park Service and monitoring data collected on harbor seals under this program may contribute to the assessment of the efficacy of the MPAs.

The information presented in this report is a summary of the harbor seal data collected at Point Reyes National Seashore and Golden Gate National Recreation Area during the 2009 breeding and molting seasons, March-July. Summary data collected as part of a region-wide survey effort, including adjacent areas (San Francisco Bay, San Mateo County, and Sonoma County) where NPS surveys were conducted in conjunction with other agencies and organizations for 2009, are also presented. This report is not intended to analyze long-term trends in the harbor seal data set, which are more appropriately investigated at five year intervals (i.e. Allen et al. 2004). Furthermore, this document is not intended to report on or analyze data specific to NPS management issues related to harbor seals.

Background

Pacific harbor seals (*Phoca vitulina richardsi*) are the dominant and only year-round resident pinniped in the San Francisco Bay Area, California. The population at Point Reyes National Seashore represents the largest concentration of harbor seals in the State of California, and accounts for approximately 20% of the mainland molting population (Lowry et al. 2005). Much of the Point Reyes coastal zone remains relatively pristine and provides good marine and

terrestrial habitat for seals to rest, molt, feed, and breed where human encroachment is minimal (Figure 1). The inaccessibility of much of the area has historically afforded some protection from human disruption during the seals' terrestrial resting periods; however, some pinniped populations in California are still recovering from a long period of exploitation that did not end until the passage of the Marine Mammal Protection Act in 1972 (Sydeman and Allen 1999). Human disturbance of seals at colonies is of interest to the National Park Service (NPS) because over 2.2 million visitors visit Point Reyes annually (NPS 2008) and several million more visit the Golden Gate National Recreation Area, many of whom visit tidepools, beaches and estuaries within the parks. The parks may implement management actions to reduce disturbance to seals at colonies, if appropriate.

Objectives

Long-term monitoring studies of harbor seals have been conducted intermittently at the largest colonies in Point Reyes National Seashore since the mid 1970's (Allen and Huber 1984; Allen et al. 1989; Sydeman and Allen 1999; Allen et al. 2004). The objectives of monitoring each site and the population as a whole are to i) detect changes in population size, ii) detect changes in reproductive success by way of pup production, and iii) identify anthropogenic or environmental factors that may affect the condition of the population. The monitoring objectives and protocol are described in detail in the *San Francisco Bay Area Network Pinniped Monitoring Protocol* (Adams et al. 2009).



Figure 1. Harbor seals resting onshore during the pupping season at Seal Island within Tomales Bay. Photograph by Sue Van Der Wal.

Methods

Study Area

The study area extends from Tomales Point to San Francisco Bay (Figure 2). The Point Reyes peninsula extends from the mouth of Tomales Bay (Lat. 38° 30'N) south to Bolinas Lagoon (Lat. 37° 30'N). Point Bonita is located in the Marin Headlands, at the mouth of San Francisco Bay in the Golden Gate National Recreation Area. For this paper, the Point Reyes sites and Point Bonita are collectively referred to as Marin County locations. Point Reyes National Seashore, Golden Gate National Recreation Area, Gulf of the Farallones National Marine Sanctuary, the California State Parks, and the county parks share jurisdiction over segments of this coastline, but overall, NPS lands account for most of the shoreline.

The topographic diversity of this coastal zone provides a broad range of substrates for harbor seals to come ashore. These include tidal mud flats, offshore and onshore rocky tidal ledges, and sandy beaches. A “haulout site” is defined as a terrestrial location where seals aggregate for periods of rest, birthing, and nursing of young (Harvey 1987; Thompson 1987). Each site, or location, is comprised of several “subsites”, or distinct areas of beach, rock outcrops, or sandbars where harbor seals haul out. Coastal embayment sites include Tomales Bay, Drakes Estero, Bolinas Lagoon, and San Francisco Bay. Coastal sites surveyed include Tomales Point, Point Reyes Headlands, Duxbury Reef, Double Point, and Point Bonita (Figure 2).

The sampling design for this program was developed so that the data could be integrated with other regional surveys, allowing for the results to be interpreted in a regional context. Annually, the National Park Service participates in regional harbor seal surveys during the breeding and molting seasons, with the Point Reyes National Seashore coordinating the central coast surveys. Regional survey sites include colonies in San Francisco Bay (Alcatraz, Mowry Slough, Castro Rocks, Yerba Buena Island, and Newark Slough), Sonoma County (Sea Ranch, South Sonoma sites, and Jenner) and San Mateo County (Fitzgerald Marine Reserve, Pescadero, Pebble Beach, Point San Pedro, Bean Hollow, and Cowell Ranch Beach) (Figure 2).

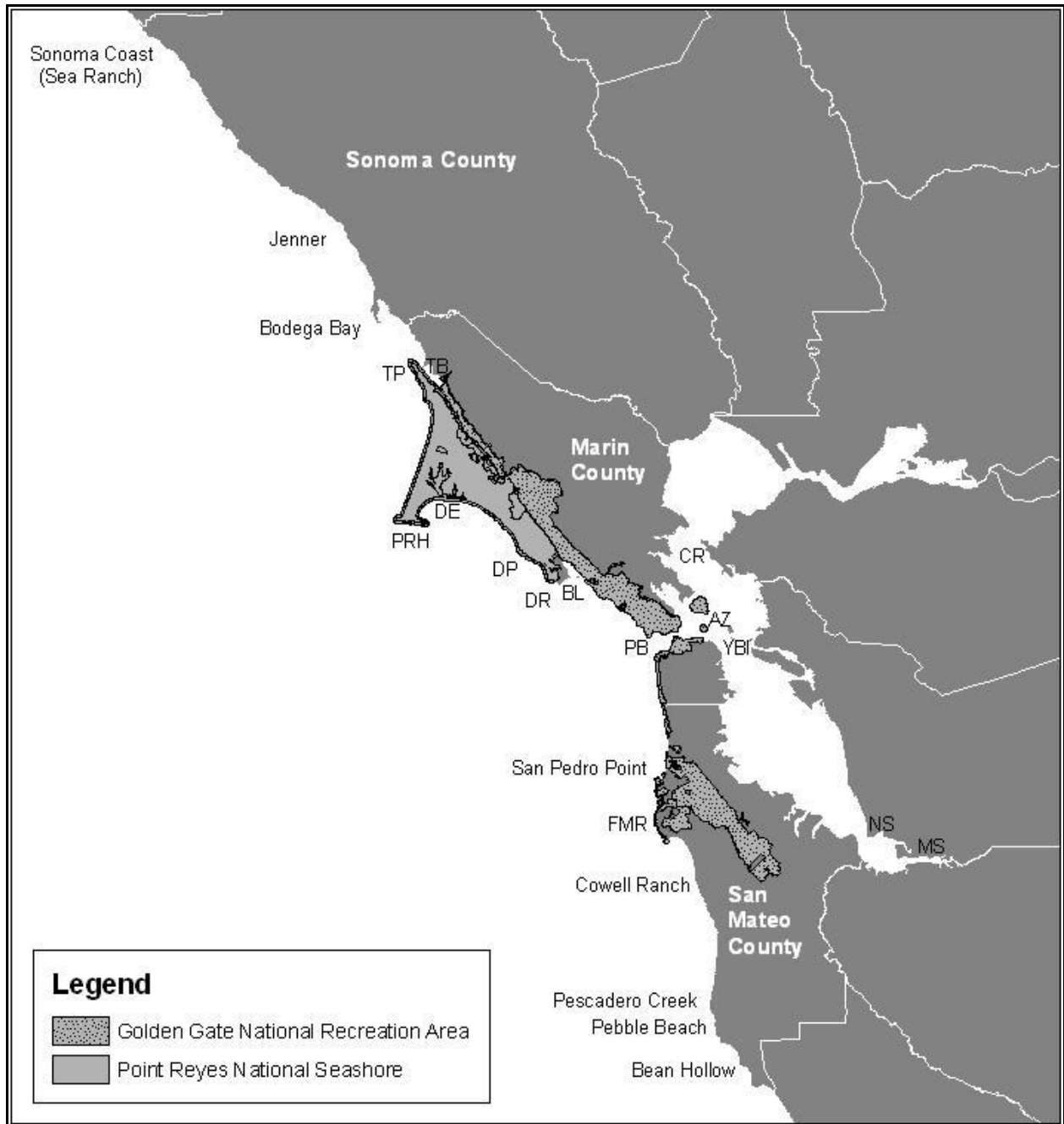


Figure 2. Regional survey sites in San Francisco Bay and Sonoma, Marin, and San Mateo counties, California. Map does not present all of the regional survey locations included in Sonoma and San Mateo counties. TB=Tomales Bay, TP=Tomales Point, DE=Drakes Estero, PRH=Point Reyes Headland, DP=Double Point, DR=Duxbury Reef, BL=Bollinas lagoon, PB=Point Bonita, CR=Castro Rocks, AZ=Alcatraz Island, YBI=Yerba Buena Island, NS=Newark Slough, MS=Mowry Slough, FMR=Fitzgerald Marine Reserve.

Surveys

Volunteer observers were trained to monitor harbor seals at designated sites within Point Reyes and at Point Bonita during two classroom and two field sessions in March 2009 (Figure 3). Many of the volunteers had been previously trained and returned to the 2009 season with several years of experience. New volunteers were required to be mentored by returning volunteers at a site before they conducted an unsupervised survey.



Figure 3. Volunteer training at Drakes Estero. NPS Photo.

Harbor seal surveys were conducted throughout the breeding (March 1st through May 31st) and molting (June 1st through July 31st) seasons once to twice per week at each Marin County location. Surveys were conducted at medium to low tides (below 3ft) during the day. Surveys were not conducted in heavy fog because of poor visibility and they were not conducted in the rain because harbor seals haul out in lower numbers in the rain (Jemison and Pendleton 2001).

Generally, volunteers surveyed for approximately 2 hours from fixed observation points with all subsites counted approximately every 30 minutes for a total of four counts each survey. Subsites were counted and recorded separately on pre-formatted datasheets and then added for site totals every half hour. Tomales Point, Bolinas Lagoon, and Duxbury Reef often had only two counts each survey due to hiking/traveling time between subsites.

For each subsite the observer recorded the time, number of adult and immature seals, pups, dead pups, red-pelaged seals, and fresh shark-bitten seals. Red pelage is easily identified and results from the deposition of iron oxide precipitates on the hair shaft; it usually extends from the head down to the shoulder and is of interest due to its rarity outside of the San Francisco Bay Area

(Allen et al. 1993). During the molting season (June-August) all animals were counted as adults or immature seals because of the difficulty in distinguishing large pups from immature seals.

On a separate data form, disturbances and potential disturbances were recorded as they occurred. Disturbances included any events that caused the seals to lift their head (head alert), flush (move towards the water), or flush into water, while potential disturbances were defined as any anthropogenic event within a defined haulout zone that had the potential to flush seals. Observers recorded the time, source, and effect of each disturbance. The information on the effect included the reaction of the seals, the number of seals that reacted, and when and where they re-hauled if they were flushed into the water. In some cases the disturbance was not directly observed, but surveyors recorded the number of animals affected with an unknown disturbance. Disturbances were recorded by fixed categories to assist with summary analyses (Table 1).

Table 1. Categories used to record disturbance sources on field datasheets.

Source	Example
Motor-boat	Motorboat, Jet ski
Non Motor-boat	Canoe, Kayak, Sailboat, Wind surfer
Vehicle	Bus, Car, Motorcycle
Dog	Dog, Dog barking
Aircraft	Airplane, Helicopter, Hang glider, Ultralight
Human	Clam diggers, Hiker, Horse rider, Oyster Worker, Researcher
Bird	Gull, Raven, Turkey Vulture
Other	Coyote, Other Pinniped, Rock Slide, etc.

On alternating weekends, regional surveys were conducted at all sites included in regional counts (see Figure 2). Participants in the region-wide surveys included various organizations and volunteers. Regional counts could be conducted at anytime between Thursday and Monday over the selected regional survey weekends.

All count and disturbance datasheets were entered into a relational Microsoft Access database during the course of the field season. At the end of the season, the database records were error-checked against the paper datasheets for accuracy. The records were further reviewed to ensure that only accurate and complete count data were used for analysis. For example, incomplete counts or counts that may have been hampered by poor weather conditions were noted in the database as poor quality surveys and excluded from analysis.

Data Management and Analysis

Although harbor seal data were collected according to subsites at each monitoring location, subsite data are not reported or analyzed within this report. By summing the subsite counts for each survey time interval, the maximum site total was identified for each survey and used for data summaries and analyses. During the breeding months of March, April, and May, the maximum total site count for each survey includes the adult/immature and pup age categories.

The maximum number of seals counted at a site over the course of the entire season is often used for comparisons between years and sites. Because there is little to no movement of harbor seals between sites during the pupping and molting seasons, it was assumed that individual animals

were not counted at more than one site (Allen 1988). The maximum total count for each year within the study area was determined by taking the sum of the maximum count at each location. The maximum total count was determined separately for the breeding and molting seasons. Maximum counts at each location may have occurred on separate days (Barlow 2002). When compiling count summaries from the harbor seal data, only records noted as high quality counts were included. During the regional survey weekends, it was not uncommon for a site to be surveyed more than once. In these cases, the survey with the greater seal count was used for any regional summaries. A regional population estimate was derived from a correction factor of 1.65 calculated in California to account for seals in the water during surveys (Lowry et al. 2005)

The total maximum counts of breeding season adults/immatures, pups, and molting season harbor seals were averaged separately across survey years 2000 to 2009 and compared to the 2009 data. Inclusion of all survey years in the average calculation accounts for the inherent inter-annual variability in the harbor seal population and in reproductive output.

When examining disturbance events, only actual disturbances, those that elicited a head-alert or flush reaction from the seals, were used for analysis. Disturbance tallies were based on disturbance sources rather than the number of subsites or seals affected. Disturbance rates were calculated as the number of disturbance events that occurred during the time period from the first observation to the end of the final observation period. Because the disturbance data were not analyzed for effects on the seal count data in this report, all actual disturbance data were used for analysis regardless of the quality of the associated seal count data. Potential disturbances (events that could potentially elicit a reaction from seals) were recorded by volunteers to quantify any given type of disturbance recurring at a particular site, but this information is not analyzed in this report. These data may be used to understand potential emerging disturbance issues at each location.

The harbor seal monitoring data are dynamic and may change over time as errors are discovered and fixed or data analysis procedures are corrected or improved. For this reason, summary data reported here for 2000 to 2009 may differ from data summaries published in previous harbor seal reports. In particular, a thorough review and update to the disturbance data occurred since the 2007 annual harbor seal monitoring report (Truchinski et al. 2008).

Results

Overall

In 2009, 49 volunteers helped to complete 227 surveys at Marin County locations between March 1st and July 31st, completing an estimated 450 hours of monitoring. Each location was surveyed between 8 and 36 times, which includes 12 regional surveys. The low survey count at Point Reyes Headlands resulted from several canceled surveys due to heavy fog. During the breeding season (March-May), a maximum of 2,353 adults and 1,018 pups were observed in Marin locations, with the numbers growing to 3,556 individuals during the molting season (June-July) (Table 2).

Table 2. Summary data of harbor seal colonies for the 2009 season. All reported numbers reflect the maximum number seen during a single census.

Location	Max # adults in breeding season ¹	Max # pups in breeding season	Max # seals in molting season ²	# Surveys	Max # reds ³	Max # shark bites ³	Max # dead pups ³
Bolinas Lagoon	281	143	429	Weekday: 23 Weekend: 12	2	7	1
Double Point	426	298	641	Weekday: 23 Weekend: 9	6	6	1
Drakes Estero	561	272	757	Weekday: 29 Weekend: 7	2	9	4
Duxbury Reef	59	3	49	Weekday: 25 Weekend: 11	0	1	0
Point Reyes Headlands	131	68	475	Weekday: 8 Weekend: 0	0	0	0
Tomaes Bay	438	89	550	Weekday: 21 Weekend: 2	0	9	1
Tomaes Point	255	129	453	Weekday: 18 Weekend: 5	1	6	2
Point Bonita	202	16	202	Weekday: 24 Weekend: 10	1	5	1
TOTAL	2,353	1,018	3,556	227	12	43	10

¹ Adults and immatures during the breeding season, March 1 to May 31.

² All age classes during the molting season, June 1 to July 31.

³ The maximum number observed March 1 to July 31.

Adult and Pup Counts During the Breeding Season

Adults: The maximum count of adult and immature seals during the 2009 breeding season was 2,353 (Figure 4). Drakes Estero had the most adults (561), followed by Tomales Bay (438) and Double Point (426; Table 2).

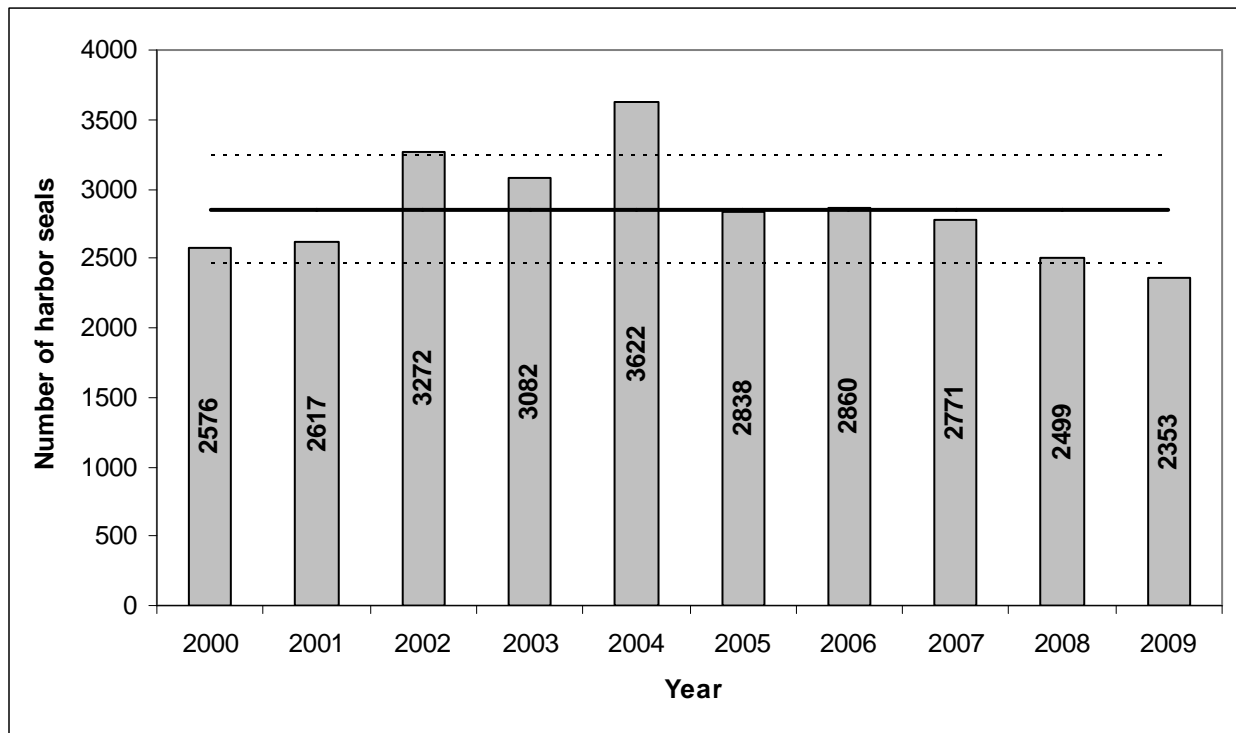


Figure 4. Maximum counts of harbor seal adults and immatures during the breeding season (March-May) for 2000-2009 at Marin County locations. The solid line on the graph represents the mean of the maximum adult counts from 2000-2009 (mean = 2,849.0) and the dashed lines represent one standard deviation from the mean (SD = 385.0).

Pups: The combined maximum pup count for all Marin County locations during the 2009 breeding season was 1,018 pups (Figure 5). Drakes Estero and Double Point accounted for 56% (570) of pups at Marin haulouts, which was consistent with the proportions of pups in the past.

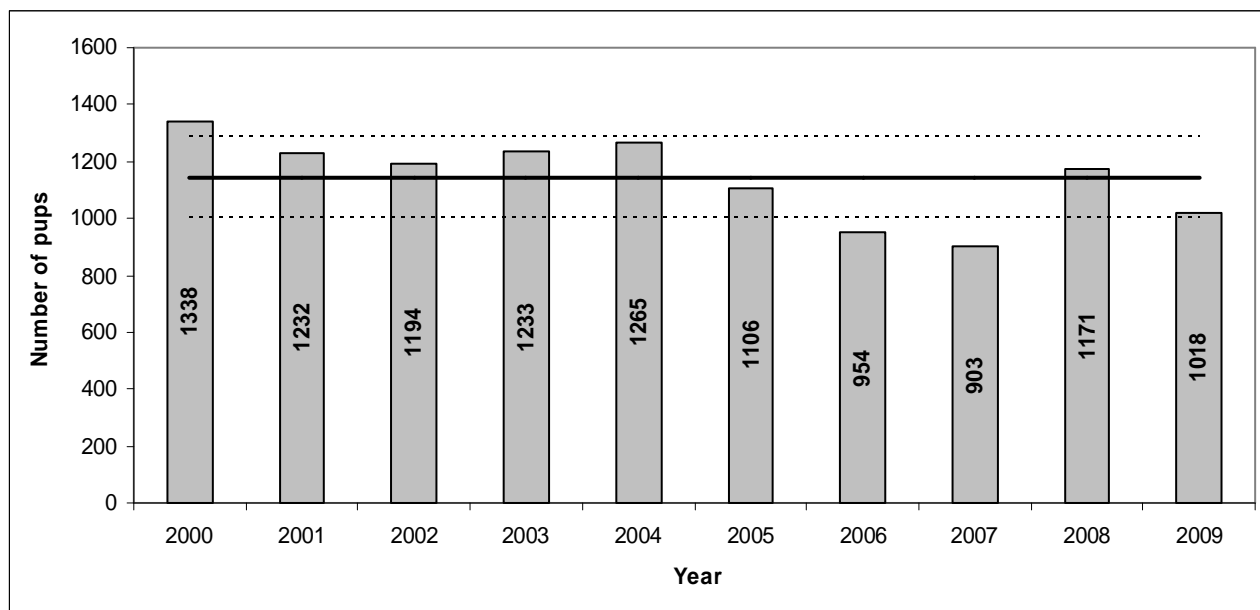


Figure 5. Maximum harbor seal pup counts for 2000-2009 at Marin County locations. The solid line on the graph represents the mean of the maximum pup counts from 2000-2009 (mean = 1,141.4), and the dashed lines represent one standard deviation from the mean (SD = 142.4).

The date of the first pup observed has been documented since 2000, and there is no apparent trend in the date or location of the first pup observed from 2000 to 2009 (Table 3). A dead pup was seen in December 2008 at Drakes Estero and was suspected to be an aborted fetus. On February 19, 2009, a pup was seen being born and nursing at Double Point. However, it was not seen during subsequent surveys and is assumed to have died. The first viable pups of 2009 were seen on March 6 at Tomales Bay.

Table 3. Date of first pup observed in the season by location, 2000-2009.

Year	Date	Location
2000	March 14	Point Reyes Headlands
2001	March 16	Tomales Bay
2002	March 3	Drakes Estero
2003	March 27	Bolinas Lagoon
2004	March 20	Double Point
2005	March 6	Drakes Estero
2006	March 9	Double Point
2007	March 2	Double Point
2008	March 16	Bolinas Lagoon
2009	March 6	Tomales Bay

All of the dominant pupping sites (Bolinas Lagoon, Double Point, Drakes Estero, Tomales Bay, and Tomales Point) decreased in maximum pup numbers from 2008 to 2009 (Figure 6). Tomales Bay experienced the largest one year difference (-25%), followed by Drakes Estero (-20%) and Tomales Point (-16%)

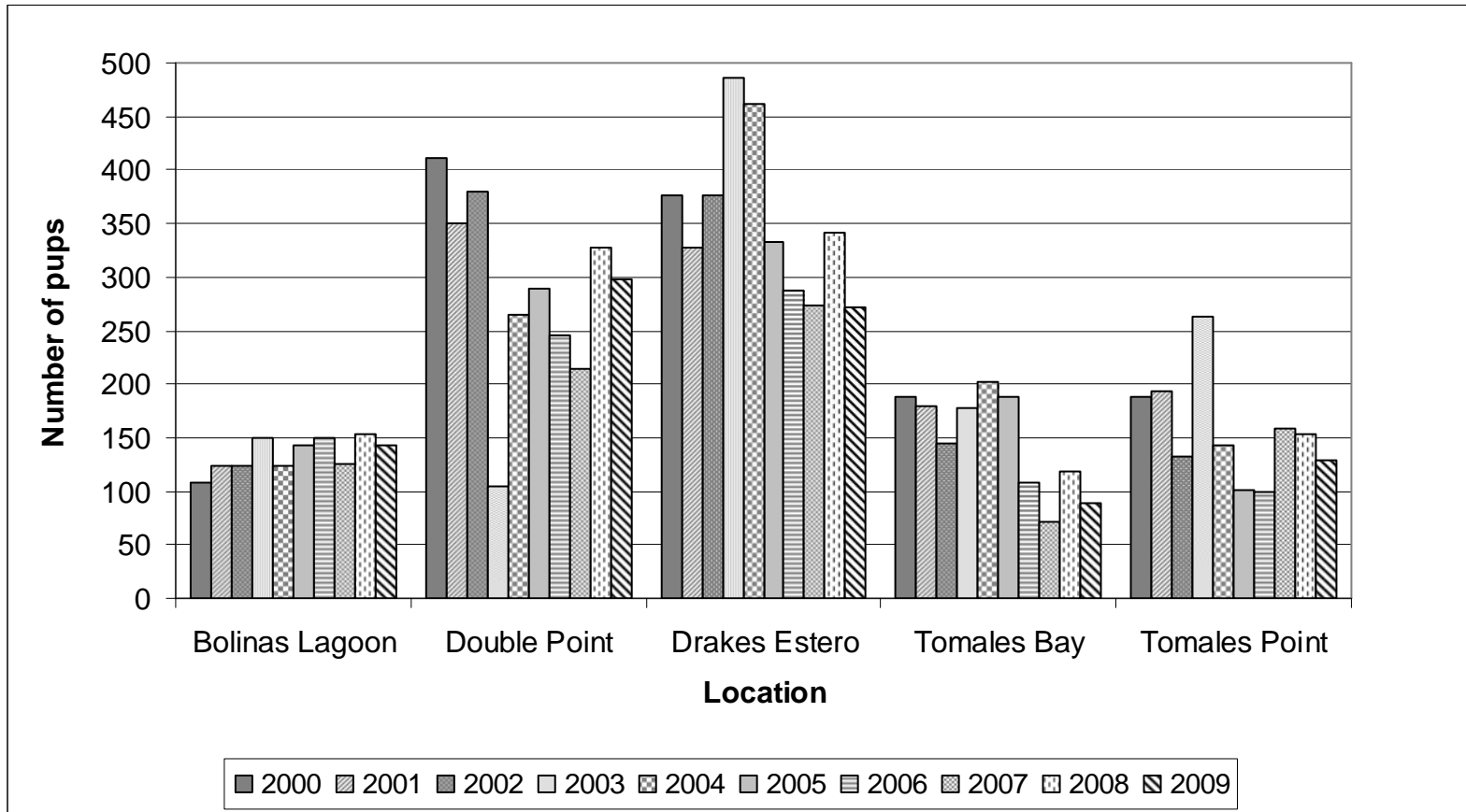


Figure 6. Maximum harbor seal pup counts at the dominant Marin County pupping locations, 2000-2009. The maximums of each site may have been observed on different days.

Molt Counts

The maximum count of all seals during the 2009 molt season for all Marin County locations was 3,556 seals (Figure 7). Drakes Estero and Double Point comprised 39% (1,398) of the total seals counted during the molt season (Table 2). This is inconsistent with previous years in that these two sites usually make up approximately 50% of the total seals counted (Flynn et al. 2009).

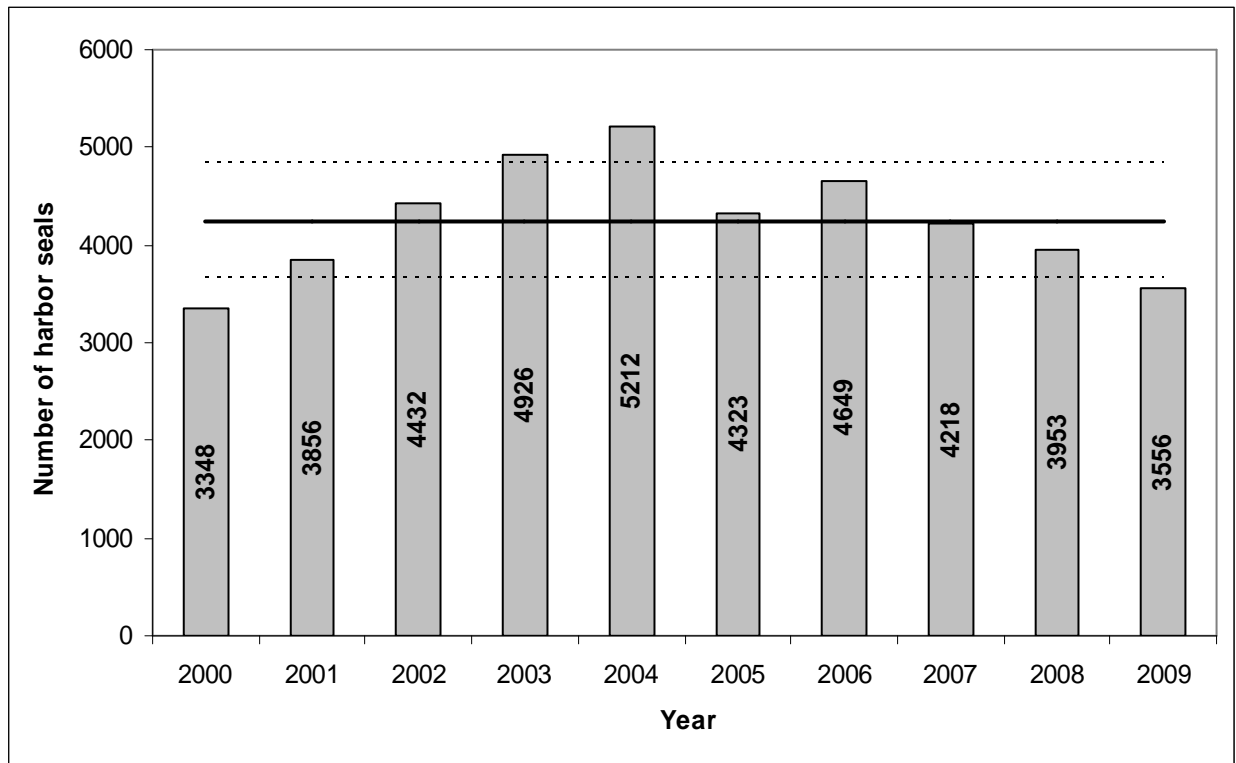


Figure 7. Maximum harbor seal counts during the molt season (June-July) for 2000-2009 at Marin County locations. The solid line on the graph represents the mean of the maximum molt counts from 2000-2009 (mean = 4,247.3) and the dashed lines represent one standard deviation from the mean (SD = 588.8).

Disturbances

At the Marin County locations in 2009, 96 disturbances were recorded that elicited a response from harbor seals, which is the second lowest number of disturbances in the study period of 2000-2009 (Table 4). The most common disturbance source was unknown (28.1%, Table 4). Motorboats and humans were the next most common sources with 22.9% and 21.9%, respectively. Tomales Bay had the highest number of disturbances (27), followed by Drakes Estero reporting 25 disturbances. The disturbances at Tomales Bay were mostly related to passing boat traffic, whereas those at Drakes Estero were primarily caused by hikers. Duxbury Reef had one disturbance and Point Reyes Headlands had no disturbances likely because of the remoteness and inaccessibility of these sites.

Table 4. Identified sources of disturbances (head alert, flush, flush into water) for Marin County locations, from March 1st to July 31st, 2000-2009.

	Motorboat		Non-Motor Boats		Vehicle		Dog		Aircraft		Human		Bird		Unknown		Other		Total
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
2000	14	11.3	9	7.3	0	0.0	0	0.0	14	11.3	23	18.5	19	15.3	43	34.7	2	1.6	124
2001	14	10.8	12	9.2	2	1.5	1	0.0	4	3.1	45	34.6	9	6.9	28	21.5	15	11.5	130
2002	19	12.1	15	9.6	9	5.7	0	0.0	9	5.7	48	30.6	11	7.0	39	24.8	7	4.5	157
2003	13	9.8	20	15.0	3	2.3	0	0.0	10	7.5	38	28.6	10	7.5	32	24.1	7	5.3	133
2004	2	2.2	9	9.7	7	7.5	1	1.1	2	2.2	35	37.6	7	7.5	23	24.7	7	7.5	93
2005	9	7.3	14	11.4	1	0.8	2	1.6	10	8.1	43	35.0	10	8.1	31	25.2	3	2.4	123
2006	14	8.9	16	10.2	5	3.2	1	0.6	8	5.1	57	36.3	13	8.3	35	22.3	8	5.1	157
2007	29	13.8	21	10.0	14	6.7	2	1.0	14	6.7	70	33.3	13	6.2	45	21.4	2	1.0	210
2008	11	10.2	10	9.3	5	4.6	0	0.0	4	3.7	51	47.2	5	4.6	18	16.7	4	3.7	108
2009	22	22.9	11	11.5	2	2.1	0	0.0	3	3.1	21	21.9	6	6.3	27	28.1	4	4.2	96
Average	14.7	10.9	13.7	10.3	4.8	3.4	0.7	0.5	7.8	5.6	43.1	32.4	10.3	7.8	32.1	24.4	5.9	4.7	133

In 2009, Tomales Bay had the greatest disturbance rate (0.70 disturbances/hr), followed by Drakes Estero (0.34; Figure 8). Of the sites that regularly have more than five disturbances per season, Tomales Point experienced the greatest change compared with 2008 with a 130% increase in the disturbance rate (Figure 9). Tomales Bay saw an increase as well, with 77%. Decreases in disturbance rates from 2008 to 2009 were seen at Point Bonita, Double Point, Bolinas Lagoon, and Drakes Estero with -44%, -39%, -30%, and -17%, respectively. The rates of disturbances vary greatly from year to year depending on activities at each location.

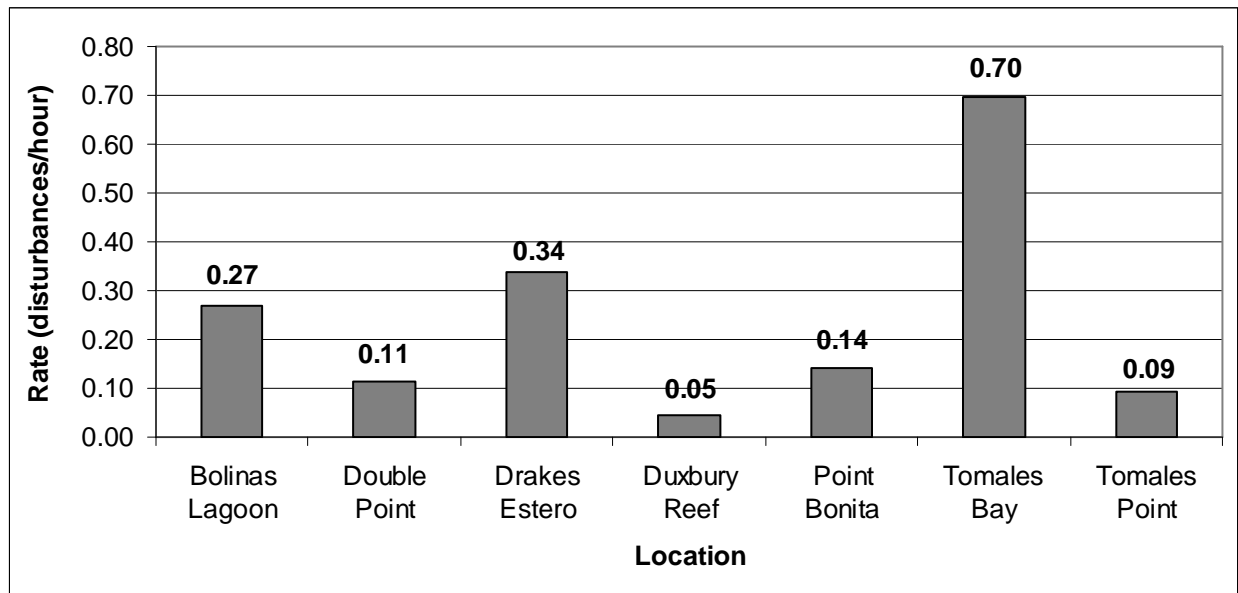


Figure 8. Rates of disturbances per hour at Marin County locations from March through July 2009. Only actual disturbances (head alert, flush, flush water) were used and survey time was based on observation time for all complete surveys (with or without disturbances).

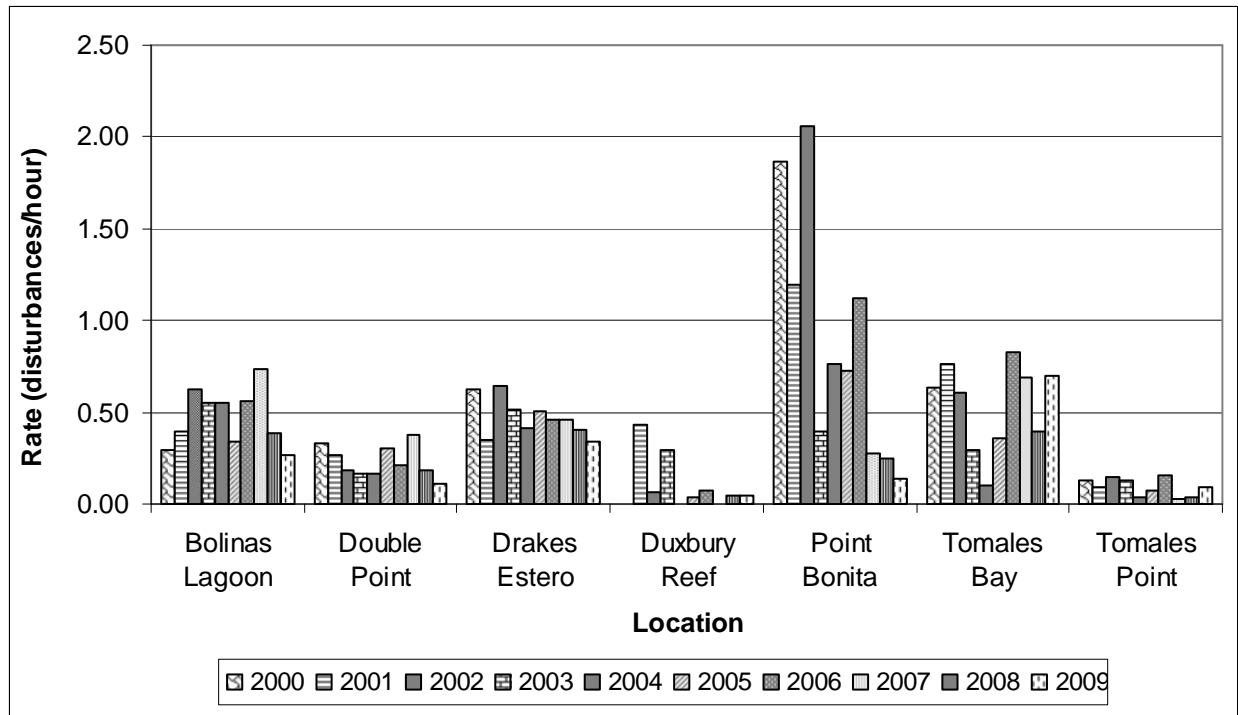


Figure 9. Rates of disturbances per hour at Marin County locations from March through July of 2000-2009. Only actual disturbances (head alert, flush, flush water) were used, and survey time was based on observation time for all complete surveys (with or without disturbances).

Summary by Site

Bolinas Lagoon

Bolinas Lagoon had 35 complete surveys between March 1st and July 31st, 2009. Of those surveys, 23 were on weekdays and 12 were on weekends. The maximum count during the breeding season had 281 adults and 143 pups. During the molting season, the maximum count was 429 seals (Table 2). Bolinas had one of the higher numbers of disturbances in 2009 and the dominant sources were non-motor boats and unknown. This site is along scenic Highway 1 and many visitors kayak in the lagoon. During one survey, a human family was seen having a picnic near a couple of seals. The 2009 disturbance rate for Bolinas Lagoon decreased from 2008 (0.38 to 0.27 disturbances/hr; Figure 9).

Double Point

Double Point had 32 complete surveys between March 1st and July 31st, 2009. Of those, 23 were on weekdays and 9 were on weekends. The maximum count during the breeding season was 426 adults and 298 pups. The molting season yielded a maximum count of 641 seals (Table 2). Double Point experienced a small number of disturbances which were all caused by unknown sources. The unknown disturbances may be caused by small rockslides from the eroding cliffs above the beaches that observers can't see or hear. Double Point had a decrease in the disturbance rate from last year (0.18 to 0.11 disturbances/hr; Figure 9) due mostly to a decrease in human and bird disturbances.

Drakes Estero

The Drakes Estero complex which includes the Limantour Spit had 36 complete surveys between March 1st and July 31st, 2009. Of those, 29 were on weekdays and 7 were on weekends. The maximum count during the breeding season was 561 adults and 272 pups and the maximum molt count was 757 (Table 2). Drakes Estero had a high number of disturbances, although, the disturbance rate decreased from 2008 (0.41 to 0.34 disturbances/hr; Figure 9). The majority of disturbances were caused by hikers on Limantour Beach due to its easy accessibility. The Estero is seasonally closed to kayaking from March to June during the critical pupping period and no kayaks were reported during this time.

Duxbury Reef

Duxbury Reef had 36 complete surveys between March 1st and July 31st, 2009. Of those, 25 were on weekdays and 11 were on weekends. During the breeding season, the maximum adult count was 59 and the maximum pup count was 3, while during the molting season the maximum seal count was 49 (Table 2). Duxbury had the lowest number of seals and only one documented disturbance, which was caused by a group of birds. Disturbances are rarely recorded at Duxbury Reef, possibly due to the low accessibility of the location.

Point Bonita

Point Bonita had 34 complete surveys between March 1st and July 31st, 2009. Of those, 24 were on weekdays and 10 were on weekends. During the breeding season, the maximum count was 202 adults and 16 pups and the maximum molt count was 202 (Table 2). An immature elephant seal was observed several times at this site. This is the second year in a row a young elephant seal has been seen at Point Bonita, however, this year there were two instances when the immature elephant seal was aggressive towards harbor seals and pinned down a couple animals. The disturbances at Point Bonita were primarily from human sources, which included fishermen and hikers that enter the closed-off area of this site. There has been a decrease in disturbances caused by humans since the area below the paved walkway was closed to visitors in mid-June 2007. Point Bonita had the largest decrease in disturbance rates from last year (0.25 to 0.14 disturbances/hr; Figure 9).

Point Reyes Headlands

Point Reyes Headlands had 8 complete surveys between March 1st and July 31st, 2009. All of the surveys were completed during weekdays. During the breeding season, the maximum adult count was 131 and the maximum pup count was 68, while during the molting season the maximum seal count was 475 (Table 2). There were no recorded disturbances at the Point Reyes Headlands. This site rarely has disturbances because of its remoteness and inaccessibility. Most of the harbor seals were seen at a large elephant seal colony pocket beach. Several survey attempts were aborted due to heavy fog that is usually present in the Point Reyes Headlands during June and July.

Tomales Bay

Tomales Bay had 23 complete surveys between March 1st and July 31st, 2009. Of those, 21 were weekday and 2 were weekend surveys. During the breeding season, the maximum adult count was 438 and the maximum pup count was 89, while during the molting season the maximum seal count was 550 (Table 2). The sandbars in Tomales Bay are a very popular spot for recreational

clam diggers, and there were often people on the sandbars during surveys. However, this year, there was only one disturbance caused by people on the sandbar. The majority of the disturbances were caused by motorboats travelling around the sandbars. Tomales Bay had the highest number of disturbances and disturbance rates of all locations in 2009 (0.70; Figure 8).

Tomales Point

Tomales Point had 23 complete surveys between March 1st and July 31st, 2009. Of those, 18 were on weekdays and 5 were on weekends. During the breeding season, the maximum adult count was 255 and the maximum pup count was 129, while during the molting season the maximum seal count was 453 (Table 2). Tomales Point experienced a small number of disturbances, the majority being caused by unknown sources. Additionally, there were a couple disturbances caused by motorboats. Due to its remoteness, however, the Tomales Point location is generally not frequented by park visitors. Abalone divers were observed during the breeding season, but they were never seen disturbing seals. However, the divers were on site before the observers arrived and therefore it is not known if the divers caused harbor seals to leave any of the haulout locations.

Regional Sites

Twelve regional surveys occurred between March 1st and July 27th, 2009 at 21 different locations. Not all sites were surveyed on all scheduled days. Weather conditions did not allow for surveys on certain days. During the breeding season, a maximum of 3,635 adults and 1,292 pups were observed, although the maximum counts may have occurred on different days for each location (Table 5). During the molting season, the combined maximum count of all seals from each site was 4,709. Marin County locations accounted for 57.6% of the maximum adult/immature breeding count, 77.6% of the maximum pup count, and 70.2% of the maximum molt count. A population estimate for the regional population of harbor seals for the molt season was 7,770 based on a correction factor of 1.65 (1.65×4709) (Lowry et al. 2005).

Within the San Francisco Bay, high counts for seals occurred at Castro Rocks and Yerba Buena Island, with the most pups at Mowry Slough. In San Mateo County the highest concentration of seals was on the coast at Fitzgerald Marine Reserve, followed by Cowell Ranch. In Sonoma County, the Sonoma Coast location accounted for the most seals this year. The results for these counties are consistent with previous years.

The majority of the disturbances in San Francisco Bay were recorded at Castro Rocks and Yerba Buena Island. The sources included vehicle traffic on the bridges, the researchers, helicopters, and motor boats. Alcatraz and Newark Slough each had one disturbance caused by a motor boat. In San Mateo County, only Fitzgerald Marine Reserve and Pebble Beach experienced a disturbance and both were caused by fishermen. Sonoma Coast did not have any documented disturbances. However, there was one occurrence when people were seen at a haulout site and the seals were in the water and not hauled out. At Jenner, kayakers, surfers, and visitors caused disturbances. During the weekend of June 27th, there was a planned breach of the Russian River which caused a decrease in the number of seals hauling out at Jenner.

Table 5. Regional surveys of harbor seal numbers in central California, March 1st through July 27th, 2009. Twelve surveys were scheduled on alternating weekends, eight during the breeding season and four during the molt. Values reported as average (Avg), standard error (SE), and maximum (Max).

	Breeding Season					Molting Season			
Location	N	Avg adults	SE	Max adults ¹	Max pups ²	N	Avg	SE	Max seals
Sonoma County ³									
Sonoma Coast	8	150.3	18.1	219	68	4	149.0	17.8	183
Jenner	8	113.8	5.2	130	27	4	192.5	66.1	295
Marin County									
Tomales Bay	7	284.3	24.6	370	75	4	358.5	72.2	550
Tomales Point	7	201.4	14.5	246	129	3	276.3	39.6	326
Point Reyes									
Headland ⁴	3	92.3	29.7	131	68	2	281.5	193.5	475
Drakes Estero	7	423.1	30.6	485	272	4	612.3	68.8	706
Double Point	7	295.9	29.3	397	298	3	477.3	85.6	641
Duxbury Reef	8	31.6	5.5	59	1	4	27.0	3.8	38
Bolinas Lagoon	8	155.1	11.6	205	143	4	327.8	17.5	367
Point Bonita	8	127.4	17.8	202	16	4	125.5	31.7	202
San Francisco Bay									
Alcatraz	7	4.6	1.0	9	0	4	3.0	1.1	5
Castro Rocks	7	166.3	23.5	244	38	4	129.0	16.5	175
YBI	7	120.0	16.5	188	14	4	100.8	9.7	125
Newark Slough ⁴	7	18.4	5.9	50	13	3	1.7	0.7	3
Mowry Slough ⁴	8	49.1	10.7	112	56	3	39.0	11.0	61
San Mateo County									
Point San Pedro	4	8.5	7.2	30	5	4	25.5	4.5	35
Cowell Ranch	5	97.4	16.2	139	21	4	107.5	11.4	135
Pescadero	6	30.2	5.2	48	9	4	28.5	4.3	41
Pebble Beach	6	62.8	13.9	105	10	4	60.8	6.4	75
Bean Hollow	6	0.3	0.3	2	0	4	7.0	3.2	15
Fitzgerald Marine Reserve	8	171.0	26.2	264	29	4	198.0	25.9	256
ALL SITES				3,635	1,292	4,709			

¹Based on the total for a single day.

²Based on the total for the same single day as above

³Fort Ross in Sonoma County has not been surveyed since 2006 and has been removed from this table

⁴Includes surveys that occurred outside of regional weekend period

Discussion

Pinnipeds are apex predators of the marine ecosystem, and numerous dynamic processes interacting together have the potential to affect their abundance, species composition and distribution. The collective knowledge gained about the recovery of pinnipeds since passage of the Marine Mammal Protection Act has been possible due to long-term monitoring programs that allow accurate interpretation of measured trends and responses to environmental and anthropogenic influences. Information gained at Point Reyes National Seashore and Golden Gate National Recreation Area contributes to predicting how recovered or disappearing populations will influence the ecosystem structure and productivity of this region.

The SFAN has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. Pinnipeds, particularly harbor seals, were selected for monitoring as an indicator of the marine ecosystem of the SFAN parks (Adams et al. 2006). Pinnipeds are one of the few species that inhabit both marine and terrestrial ecosystems; they forage and travel in the coastal waters of the parks but come onshore to rest, breed and molt. They reside in estuaries such as Tomales Bay, in rocky intertidal zones such as at Point Bonita, along pocket beaches such as at Tomales Point, and on islands such as Alcatraz. They also occur in special management zones such as wilderness areas and marine protected areas such as Point Reyes Headland and Drakes Estero, Harbor seals are sensitive to changes in the marine ecosystem and respond quickly to changes in prey abundance and distribution, and to human disturbance (Allen et al. 1985; Thompson and Miller 1990; Trillmich and Ono 1991; Thompson et al. 1998; Sydeman and Allen 1999).

From 2000-2009, Drakes Estero and Double Point annually produced the highest numbers of harbor seal pups. In 2009, these two sites combined produced 56% of the pups observed at Marin County sites. Along with Tomales Bay, these two sites also make up the largest numbers of adults and immatures observed during the breeding season. The 2009 breeding season had the lowest number of adults and immatures recorded during the 10-year study period. From 2000–2008, Drakes Estero and Double Point comprised at least 50% of the seals recorded during the annual molting season. However, in 2009 these sites only made up 39% of the total seals recorded.

Throughout the study area from 2000-2009, the primary sites that experienced disturbances were Bolinas Lagoon, Drakes Estero, Point Bonita, and Tomales Bay. Disturbances at Point Bonita have decreased since the area was closed to visitors in mid-June 2007. In 2009, Tomales Bay had the highest number of disturbances recorded, with the majority being caused by motorboats. From 2001-2008, human activity, excluding boats and vehicles, was the most common source of disturbance at Marin County locations. However, the most common disturbance source in 2009 was unknown. This category is used when the surveyor observes seals displaying a disturbance response, such as head alert, flush towards water, or flush into water, but the source cannot be identified. The next most common disturbance sources were motor boats and humans

Season Highlights

- A maximum of 2,353 adults/immatures seals were counted onshore during the breeding season. This is the lowest number recorded in the past 10 years.

- The greatest number of adults hauled out at Drakes Estero (561), followed by Tomales Bay (438) and Double Point (426).
- A maximum of 1,018 pups were observed at Marin colonies.
 - Drakes Estero and Double Point accounted for 56% (570) of pups at Marin colonies.
- A maximum of 3,556 animals were counted during the molting season at Marin County haulout sites.
 - Drakes Estero and Double Point comprised 39% (1,398) of the total seals counted during the molt season, which is a smaller proportion than previous years.
- 96 disturbances were recorded during surveys.
 - The most common categories for disturbances were unknown (28.1%), motor boat (22.9%), and human (21.9%).
- Regional surveys occurred 12 times throughout the breeding and molt seasons, which include Sonoma, Marin, San Francisco, and San Mateo counties. Eighteen volunteers participated in these surveys.
 - Marin County locations accounted for 57.6% of breeding season adults/immatures, 77.6% of pups, and 70.2% of seals during the molting season.
- 49 volunteers completed 227 surveys at Marin County locations between March 1st and July 31st 2009, contributing approximately 450 survey hours.

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